of these branches, as well as the hardness and rigidity of these peculiar cells, together with their great number, we must assume that they serve as a mechanical contrivance to prevent the collapse of the wide air-passages which, without them, might take place on a sudden or gradual change in the radial pressure exerted on the plant by the water and the atmosphere.

This summer I planted a cluster of the spur-like rootlets mentioned above in some sand contained in a shallow dish and covered with a few inches of water. The bud above the rootlets soon sent up some of the submersed leaves, which, in shape and size, exactly resembled the ones collected from the actual habitat of the plant. But on closely examining their petioles I was surprised to find that they did not contain a single stellate cell! I do not venture to consider this single observation as a proof of the correctness of the above theory, but it certainly does not contradict it, and invites closer investigation.

Hoboken, December 1884.

EXPLANATION OF PLATE XLVIII.—Fig. 1. Cross-section of filiform stem. *e*, epidermis; *se*, sub-epidermal layer of parenchyma consisting of two or three rows of cells with few and small interstices; *i*, intercellular air-canals; *ic*, air-canal magnified in Fig. 8; *p*, partitions between air-canals; *cb*, central fibro-vascular bundle; *lb*, lateral bundles; x 36. Fig. 2. The central fibro-vascular bundle of Fig. 1, x 370. *en*, endodermis; *v*, ducts (annular and spiral); *sv*, sieve tissue. Fig. 3. Central fibro-vascular bundle of filiform petiole. Letters as in Fig. 2; x 370. Fig. 4. A few of the numerous stems, leaves, etc., of a full grown plant to illustrate its habit. The filiform petioles and stems of the original were about .5$^{m.}$ long. *bt*, bottom of lake; *sl*, submersed leaves, *sc*, scales; *pt*, filiform petioles; *st*, filiform stems; *sp*, spur-like roots; *sf*, surface of water. Fig. 5. Bases of leaf-organs. Letters as in Fig. 4. Fig. 6. Young plant that has grown from the spur-like roots, *sp*. Fig. 7. Cross-section of one of the spur-like rootlets (Fig. 4). *e*, epidermis; *pc*, parenchyma cells; *en*, endodermis; *v*, ducts; *sv*, sieve-tissue; x 36. Fig. 8. Intercellular canal, *ic*, Fig. 1, x 36. *sh*, stellate "hairs"; other letters as in Fig. 1. Fig. 9. Longitudinal section through air-canal and stellate "hair"; x 370. Fig. 10. Longitudinal section through air-canal, giving front-view of stellate "hair", the invisible half of which extends behind the partition into the contiguous air-passage; x 370.

All the powers given refer to the original figures as drawn with the camera; in the plate they appear reduced to one-half their size.

On the Mechanism of Anthesis in the Ericaceæ

By H. H. RUSBY.

As to the anthers, a strong distinction exists between the Pyrolineæ and the remainder of the Ericaceæ, in that the pores are basal in the former, apical in the latter. But this characteristic is not so readily made out as would at first appear. On examining a mature flower in any sub-order, the pores are found uppermost, and the only apparent indication of inversion in the Pyrolineæ is the common extrorseness of the pores, the anther itself being introrse. But even this distinction vanishes, nearly, in *Clethra*, where the poriferous horns are twisted so as to face laterally, and quite so in *Chimaphila*, where the horns are very short, and the openings look obliquely upward and inward. When we turn to the bud of *Clethra*, we find the filament doubled upon itself, so that the poriferous horns are pointing downward. In very young buds this reduplication of the filament is not apparent, the fold be-

ing so closely appressed to the anther. When, now, we read that the anther in Pyrolineæ is "normally extrorse in the bud" and that the pores are "really basal," the ordinary inference must be that it is this folding of the filament that constitutes the normal condition, and renders the pores truly basal. But again we are puzzled on finding that this same folding of the filament, producing reversion of the anther, in the bud, prevails in a number of genera of Ericineæ, particularly in the first and second tribes. Why then should the same condition be called normal in one case and abnormal in the other? Why should pores similarly placed be called basal in the one sub-order and apical in the other? Why should *Arctostaphylos* and *Arbutus* form one extreme, and *Clethra* and *Pyrola* the other, of a large family, the intervening genera differing in the most important characteristic in which these extremes agree? An answer is found in the existence in the Pyrolineæ of a second fold or turn of the filament at its point of attachment, thus placing it erect in the bud, and inverted in the flower, when the larger first fold has become obliterated. A careful study of this subject has proven so interesting that my observations have been committed to paper, and, with a few diagrams, are here given.

Fig. 1.

Fig. 2

Fig. 3.

Fig. 4.

I shall speak of the primary, obscure fold in Pyrolineæ as an *inversion*, which it really is, and the more evident, secondary fold, common to many genera, as a *reversion*. Suitable buds for this study not being commonly collected, I heve been unable to examine some genera at all, and in several others the buds were so old as to leave the truth merely inferential.

Inversion has been clearly demonstrated in *Clethra*, *Chimaphila* and *Pyrola*—*Moneses* not having been examined.

Reversion is certainly present in *Arbutus*, *Arctostaphylos* and *Cassiope*, and probably in *Gaultheria* and *Cassandra*. It has been excluded in *Leucothoe*, *Oxydendron*, *Epigæa*, *Andromeda*, *Calluna*, *Ledum* and *Rhododendron*. In *Menziesia*, so far as my observations go, it is very doubtful, and the other genera I have had no opportunity of examining.

My observations began with the study of *Arctostaphylos*, in February, 1881, when among the mountains of South-eastern Arizona I was waiting for the spring flowers to open, only *Arctostaphylos pungens*, HBK., *Brodiæa pauciflora*, Wats., and *Carphochæta Bigelovii*, Gray, being in flower.

The drawings made at that time are lost, but the plan of reversion

and restitution, being much the same as in *Arbutus*, I may illustrate by reference to figures of that genus. Fig. 1 illustrates a mature stamen of *Arbutus Menziesii*. The anther is erect, introrse both as to position and pores, attached very near its upper extremity, and furnished with a pair of curved horns projecting backward, the concavity of the curve looking directly upward. These horns seem to have their origin at, or very near, the upper edge of the pore, and to be adnate to an extent which varies in different genera and species, and in the same species at different periods. If now, we imagine this anther tipped over backward until it is exactly upside down, we shall have a part of what we find in Fig. 2, an illustration of a stamen from a young bud of the same species. That is, the anther would be reverted, and extrorse as to both position and pores, and the filament folded upon itself. But the horns would assume a different position, for they would project inward, the concavity of the curve looking directly downward. Such, however, is not the case in the bud. The filament is bordered by thin, but strong, transparent wings, and to this the horns

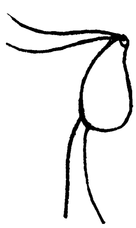

Fig. 5.

Fig. 6.

Fig. 7.

are firmly attached, apparently imbedded in its substance. The filament is at this time very short. From these observations, the design of the arrangement, and the use of the horns is very apparent. As the filament lengthens in its narrow quarters it becomes variously curved and cramped, so that at the first intimation of freedom, from the spreading of the corolla, which it probably hastens, it begins to straighten by pressing the anther in the only direction possible, namely, the apex (lower end) outward. It is evident that powerful assistance must be rendered by the elasticity of the growing horns, pressed, as they are, far out of their normal line. (See also Figs. 3 and 4.)

In *Arctostaphylos* the principle is the same, with slight differences in the details. It must be remarked that in this genus especially, the development and growth of the horns is very rapid. In the youngest buds that can be readily examined, the horns are scarcely discernible. The rapidity of their subsequent growth is well seen by comparing their length in the five precocious, with that in the other five anthers (best seen in *Arctostaphylos Uva-ursi*), for in all of these changes, five

of the anthers are constantly much in advance of the others. In this genus they become much longer, and instead of being, in the bud state, imbedded in the substance of a transparent wing of the filament, they are attached thereto by abundant glutinous hairs belonging both to themselves and to the filament. Here, at least, the horns apparently have some part in cross-fertilization. In *A. glauca* they are so far doubled backward that their hairy and glutinous tips are approximated to the anther pores, so that being jarred by departing insects, a quantity of the pollen is shaken out upon them, to be held until the arrival of the next visitor. Futher evidence of the flowers being proterogynous was found in the presence, among the filaments and upon the viscid stigma, of a considerable quantity of pollen before the anthers of those flowers were yet mature. A large number of flowers was found punctured near the base with a large, angular aperture. Careful and long continued observation placed the mischief to the account of a humming-bird, which passed a large part of its time among the shrubs.

Cassiope does not differ essentially from *Arbutus*. Its horns are like those of *Arbutus* in slenderness, but are not quite so long, and are rather straighter.

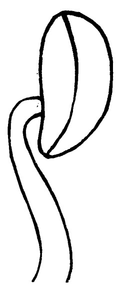

Fig. 8.

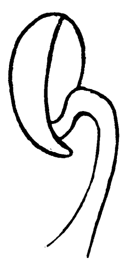

Fig. 9.

The stamens of all the above genera agree in two important particulars: the filaments are attached quite near the apex of the anther, and the latter possesses backwardly projecting horns. Both these characters, as we have seen, are useful in overcoming the reversion of the anther. Now in *Gaultheria*, of which I have but a single bud to examine, and that an old one, we see the first step toward a condition in which both these characters are wanting, and where the anthers are never reverted. For in *Gaultheria* we have the "dorsal" awns, but the filament is not attached near the apex of the anther. (Fig. 5.)

In *Cassandra* (Fig. 6) the mechanism is still farther lost by the insertion of the filament near the lower end of the anther, and the almost straight direction of the stout horns, which thus become beaks. Here we are obliged to entertain the question as to the dorsal horns of *Arbutus* being the homologues of the terminal beaks of Vaccineæ (and *Cassandra*, etc.) which have become narrowed, recurved, and broken through at the base on the inner side to form the ventral pores.

As above stated, in neither of the two last genera was reversion clearly seen, and it was clearly excluded in all the others examined up to Pyrolineæ. But, in passing, one would call attention to the

existence of beaks in the thecæ of *Andromeda Mariana*. Fig. 7 illustrates a stamen from a rather young bud. The beaks, here so distinct, become less so as the flower matures, by their close approximation and adherence below. In the other species of that section, they are, even in the young state, beakless as described.

We now come to consider a very different condition, best seen in *Pyrola*. Fig. 8 represents a stamen from a moderately developed bud of *P. rotundifolia*. Here we see the same folding of the filament (reversion) as in the first class of cases, the poriferous extremities of the thecæ pointing downward, but at the same time inward. In the last particular they differ from all the above genera, and point to the inversion which is clearly shown in Fig. 9. In this case, one theca has been torn away, so that the direction of the fibres of the filament can be plainly seen at their actual point of insertion, again turning upward to become continuous with the connective. If, with a needle, we attempt to strip off the filament in a downward direction at the point *a*, we succeed in getting a transverse fracture at that point; while the same experiment with an anther of *Arbutus* similarly prepared results in the splitting off of the filament to the extreme end

Fig. 10.

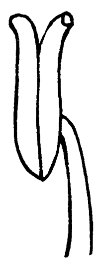

Fig. 11.

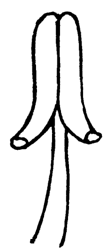

Fig. 12.

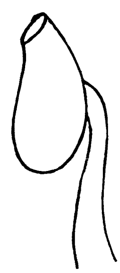

Fig. 13.

of the connective. It is clearly, then, this folding of the filament, hidden between the thecæ, that produces the inversion proper, and proves the anther to be erect in the bud, and the pores to be basal; notwithstanding that in the mature flower they are uppermost. As to the direction of the pores, it is evident that, pointing inward in the bud, their normal position, they must point outward in the flower, when the inversion has become effective by the disappearance of the counterbalancing reversion.

This extrorseness of the pores is permanent in *Pyrola*, but not in *Clethra* or *Chimaphila*, and in that genus it is overcome, at least partially, by the unilateral depression of the anthers. But in *Clethra* (Fig. 10, stamen from bud, Fig. 11, from mature flower) the beaks are elongated, divergent and twisted, so that the pores face laterally or nearly so. In *Chimaphila* (Fig. 12, bud-stamen of *C. maculata*, Fig. 13, flower-stamen of the same), the pores are practically introrse The manner in which they have become so is not clear, for in my only bud I found them extrorse in their reverted condition, and it is not known to how early a period this relation could be traced.

Some one will probably find a study of the buds of *Rhododendron* very interesting during the coming season.